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Sub B1> # M thod, device and auxiliary joining part for effecting a mechanical joining

Sub A1> The invention relates to a method, a device and an auxiliary joining part for mechanical joining by means of punch riveting according to the generic terms of Claims 1, 5 and 8.

Sub B3> In known punch riveting with semitubular rivets the auxiliary joining part (the rivet) is joined into the sheets to be joined by a linear movement without a prepunched hole.

In known clinching a punch penetrates during the working stroke in a linear motion into the sheets to be joined, whereby on the opposite side a solid or split die takes part in forming the die side of the clinch spot. A counterpunch is positioned in the split die.

The known wobbling movement is used for the forming of a rivet head on the face side by partial compressive deformation.
This movement is also used in clinching, i.e. joining without using an auxiliary joining part (DE 198 43 874.5).

In known punch riveting heavy forces are required during the linear punch motion. Therefore the tool load is high which limits the application for high-strength sheet materials.
Sub A2> For the C-frames preferably used as tool frames, heavy forces limit the daylight and hence, the applicability of the method.
Sub B4> Due to the flow of the sheet material and the additional deformation of the auxiliary joining part, a specific shape of the joint results during the linear punch movement.

It is the objective of this invention to reduce the forces occurring in punch riveting. This aims at extending the field of application of this process concerning high-strength materials and the accessibility of C-frames for large workpieces. It is another objective of this invention to eliminate the process's weak points of drawing-in of the head and low expansion and thus to achieve a better appearance and higher joining strengths in equivalent joining jobs.

Sub A3> According to the invention, the problem is solved by a method with the features mentioned in Claim 1 in which, during the axial feeding motion of the semitubular rivet, the upper tool or/and a portion of the lower tool are given a wobbling additional movement in radial and/or tangential direction.

This additional movement is superimposed on the axial feeding motion during the whole or part of the joining process. The wobbling movement can take place tangentially, e.g. in a circular motion, radially outwards from the centre, e.g. in a pivoting motion, and in a combined motion tangentially/radially, e.g. in a rosette kinematics. Due to the wobbling movement the material is partially deformed which distinctly reduces the process forces.

Sub a4 Advantageously, for punch riveting with semitubular rivet rivets are used with material accumulated in critical areas.

It is also advantageous, for a simultaneous active additional movement of the upper tool and a portion of the lower tool, to make these move synchronously such that the introduced axial forces of the punches oppose each other directly.

Sub a5 According to the invention, the problem is further solved by a device in connection with the features mentioned in the generic term of Claim 5 whereby the upper tool or/and a portion of the lower tool as counterpunch can be moved in a wobbling manner in radial and/or tangential directions.

In the device according to the invention, at least one of the tools (upper tool, a portion of the lower tool as counterpunch) is displaced in a wobbling manner in addition to the known axial feed motion. Both opposing tools can execute this wobbling motion simultaneously and, in a special embodiment, synchronizedly.

Advantageously, the die of the device is a split die. This allows to realize a special material flow on the die side of the joint.

In an embodiment of the device with only the upper tool wobbling, the lower tool, which in other cases is split, is designed as a one-piece part.

Sub a6 According to the invention, the problem is further solved by an auxiliary joining part in connection with the features mentioned in the generic term of Claim 8 whereby the semitubular rivet is provided with material accumulations in critical areas.

Advantageously, the rivet has a convex elevation at the rivet head.

It is also advantageous that the inner and outer profiles of the semitubular rivet are described by two tractrix curves in each case whereby the start points of the curves are situated in direction of the rivet foot and rivet head, respectively, and the transition of the curves is tangential in the centre.

In the following, the invention is further explained by examples of embodiment. In the drawings it is shown by

Fig. 1 a representation of state-of-the-art punch riveting;

Fig. 2 a semitubular rivet according to the invention;

Fig. 3 a representation of punch riveting with superimposed wobbling movement.

In **Fig. 1** the known punch riveting with punch **1** and fixed die **2** is represented. The standard semitubular rivet **3** penetrates in an axial movement into the sheets to be joined **4** and **5**. This rivet usually has a flat head **3a**, a radius **3b** and a chamfer **3c**.

In **Fig. 2** a semitubular rivet **6** adapted to the wobbling movement is shown. It has a material accumulation in form of a convex elevation at the rivet head **6a**. Therefore the introduced force is concentrated mainly on the area of the rivet head centre in the first period of the process, wherefrom the cutting forces to cut the upper sheet are passed to the rivet foot. The periphery of the rivet head is plastified only at the end of the joining process, when the entire rivet head is formed flat. The additional rivet material of the convex elevation is displaced radially outwards during flat forming. With the resulting increase of the rivet head diameter the drawing-in zone **12** in the upper sheet is reduced.

Further the contours of the semitubular rivet **6** are described by two tractrix curves each.

The start points of the tractrix outer contour are situated at the rivet foot (curve **6c**) and rivet head (curve **6b**). The start points of the tractrix inner contour are also at the rivet foot (curve **6e**) and at the upper point of the inner contour (curve **6d**).

Sub B> The inner curves **6d** and **6e** and the outer curves **6b** and **6c** are connected to each other by a tangential transition. This aims at increasing the cross-sectional area of the rivet, which is an annular area in the lower portion and a circular area in the upper portion, continuously beginning from the rivet foot. Therefore, in every cross-section, the bending moment which in-

creases beginning from the rivet foot during joining can be taken into account and no weak points develop at chamfer or radius, respectively, transition points. Owing to this design of the auxiliary joining part the loads developing during partial deformation can be absorbed in an improved way and the undesired compression of the rivet foot can be reduced. A better expansion develops and hence a higher strength of the joint.

In **Fig. 3** the riveting process with superimposed wobbling movement **11** is shown in its final phase. As a wobbling movement **11** a movement is superimposed that describes a rosette or a circle. The synchronizedly wobbling tools, upper tool **7** – punch – and lower tool **8** – here the counterpunch as portion of the lower tool – swivel at a maximum wobbling angle **10** whereby this angle is between 1° and 10°, preferably 3°.

**N menclature**

1 – punch
2 – fixed die
3 – standard semitubular rivet
3a – flat head
3b – radius
3c – chamfer
4 – punch-side sheet
5 – die-side sheet
6 – semitubular rivet
6a – convex elevation at the rivet head
6b – upper smaller tractrix curve at the outer contour
6c – lower bigger tractrix curve at the outer contour
6d – upper smaller tractrix curve at the inner contour
6e – lower bigger tractrix curve at the inner contour
7 – upper tool
8 – portion of the lower tool
9 – split die with inner cone
10 – wobbling angle
11 – wobbling movement
12 – drawing-in